VA #1 California's Channel Islands

San Miguel

Santa Rosa

Devils Peak
2,450 ft (747 m)

Santa Cruz

Anacapa

Santa Barbara

San Nicolas

PACIFIC OCEAN

Santa Catalina

San Clemente

CALIFORNIA

N
W   E
S

0   25   50
Miles

VA #2 Depiction of Prehistoric Channel Islands

Deepest point in the Channel 2,010 feet

Devils Peak 2,450 ft (747 m)

Present-day San Miguel

Santarosae

Present-day Santa Rosa

Present-day Santa Cruz

Present-day Anacapa

Santa Barbara

PACIFIC OCEAN

San Nicolas

Santa Catalina

San Clemente

CALIFORNIA

N
W   E
S
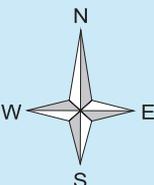
0   25   50
Miles

Sea level around islands at last ice age (1.8 million years ago ending about 2,000 BCE)
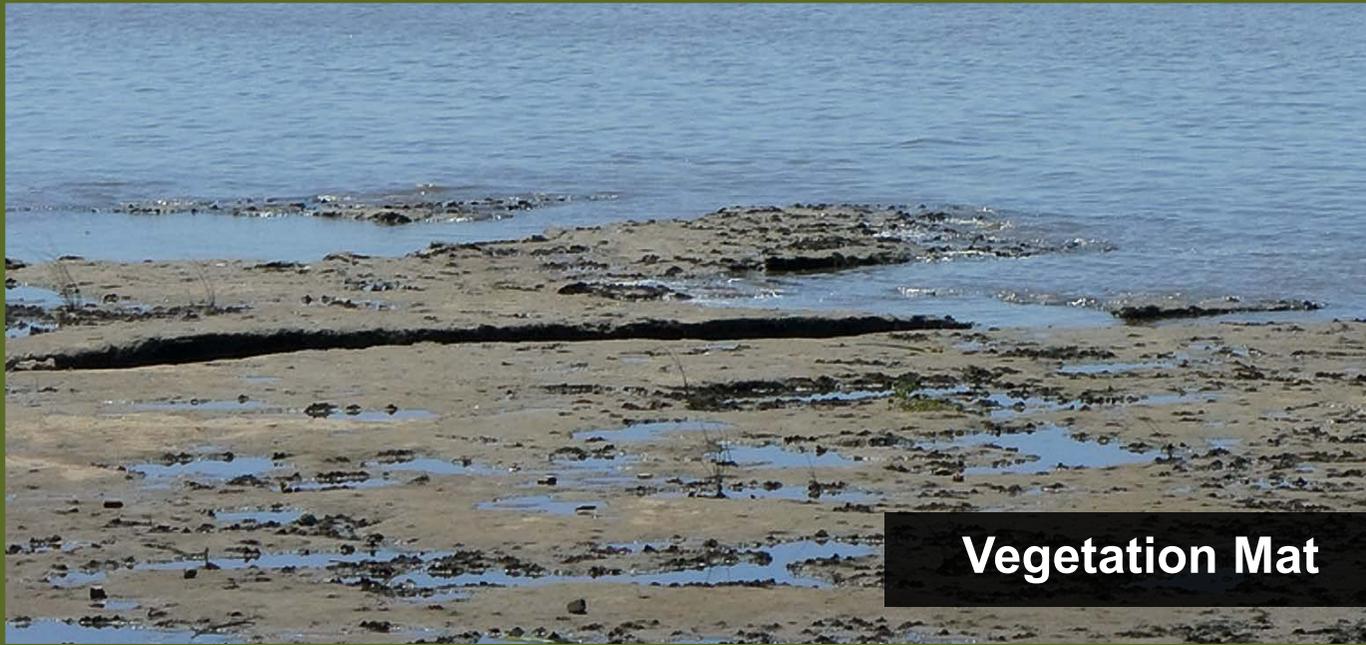
Vegetation Mat

Swimming to an Island

VA #4 Dispersing to Islands

Organism	Probability of arriving on the Islands (High or Low)	Rationale	Mechanism of Arrival
Large land mammal			
Small land mammal			
Marine mammal			
Bird			
Reptile			
Amphibian			
Plants			
Any organism introduced by humans			

VA #5 Distribution of Abert's and Kaibab Squirrels

Grand Canyon
National Park, Arizona

IDAHO

WYOMING

UTAH

COLORADO

Yampa

Green

Colorado

Gunnison

Dirty Devil

Kaibab squirrel
Sciurus aberti kaibabensis

San Juan

GRAND
CANYON

Virgin

Colorado

CALIFORNIA

ARIZONA

Little Colorado

NEW MEXICO

Colorado

Verde

Colorado River Aqueduct

Abert's squirrel
Sciurus aberti

Gila

N
W   E
S

| 0 | 100 | 200 | 400 |

Miles
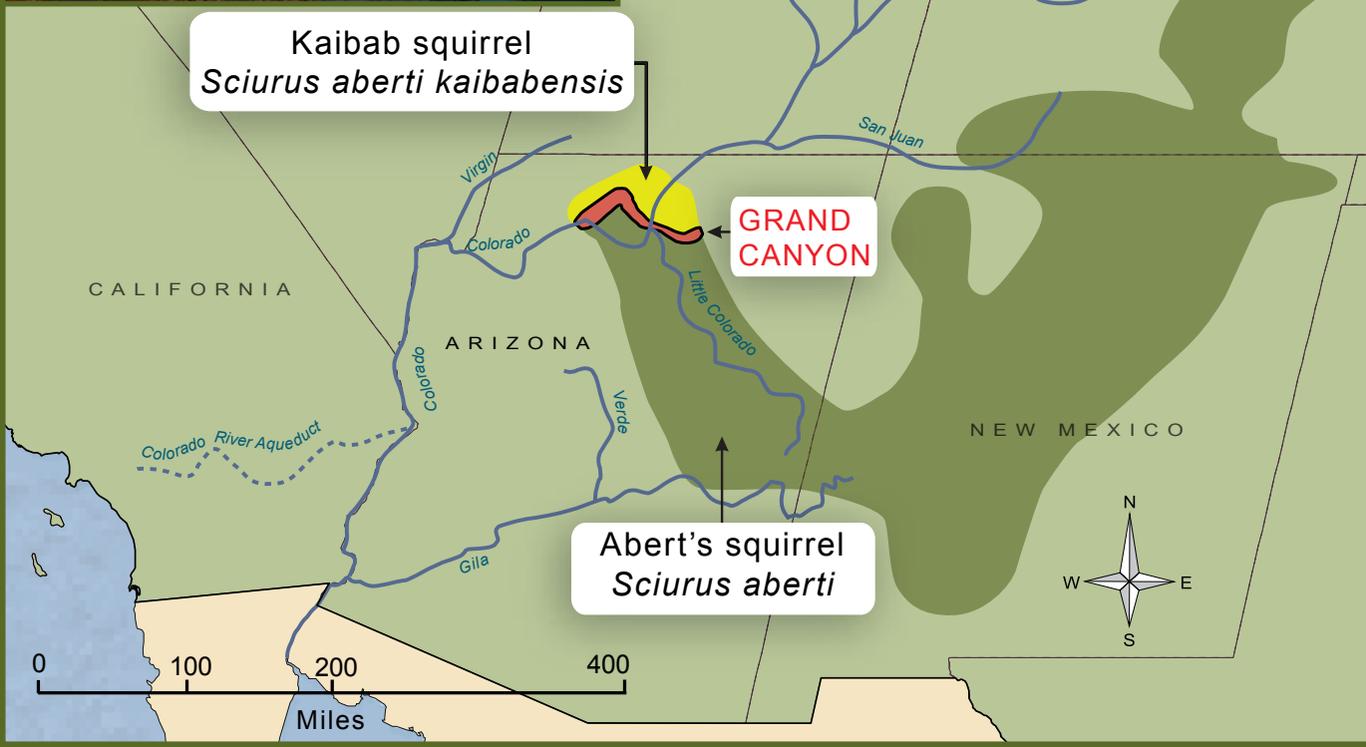
VA #8 Island Fox versus Gray Fox

Island Fox

Gray Fox

Island Scrub-Jay

Western Scrub-Jay

VA #10 Island Redberry versus Redberry (Mainland)

Island Redberry

Redberry (Mainland)

VA #11 Galápagos Islands

PACIFIC OCEAN

PINTA

MARCHENA

GENOVESA

Equator

SANTIAGO

BARTOLOMÉ

SEYMOUR NORTE

BALTRA

RÁBIDA

FERNANDINA

PINZÓN

SAN CRISTÓBAL

ISABELA

SANTA CRUZ

SANTA FE

TORTUGA

N

W E

S

FLOREANA

ESPAÑOLA

0   50

MILES

Domed Shell

Saddleback Shell

Cheetah

Lion
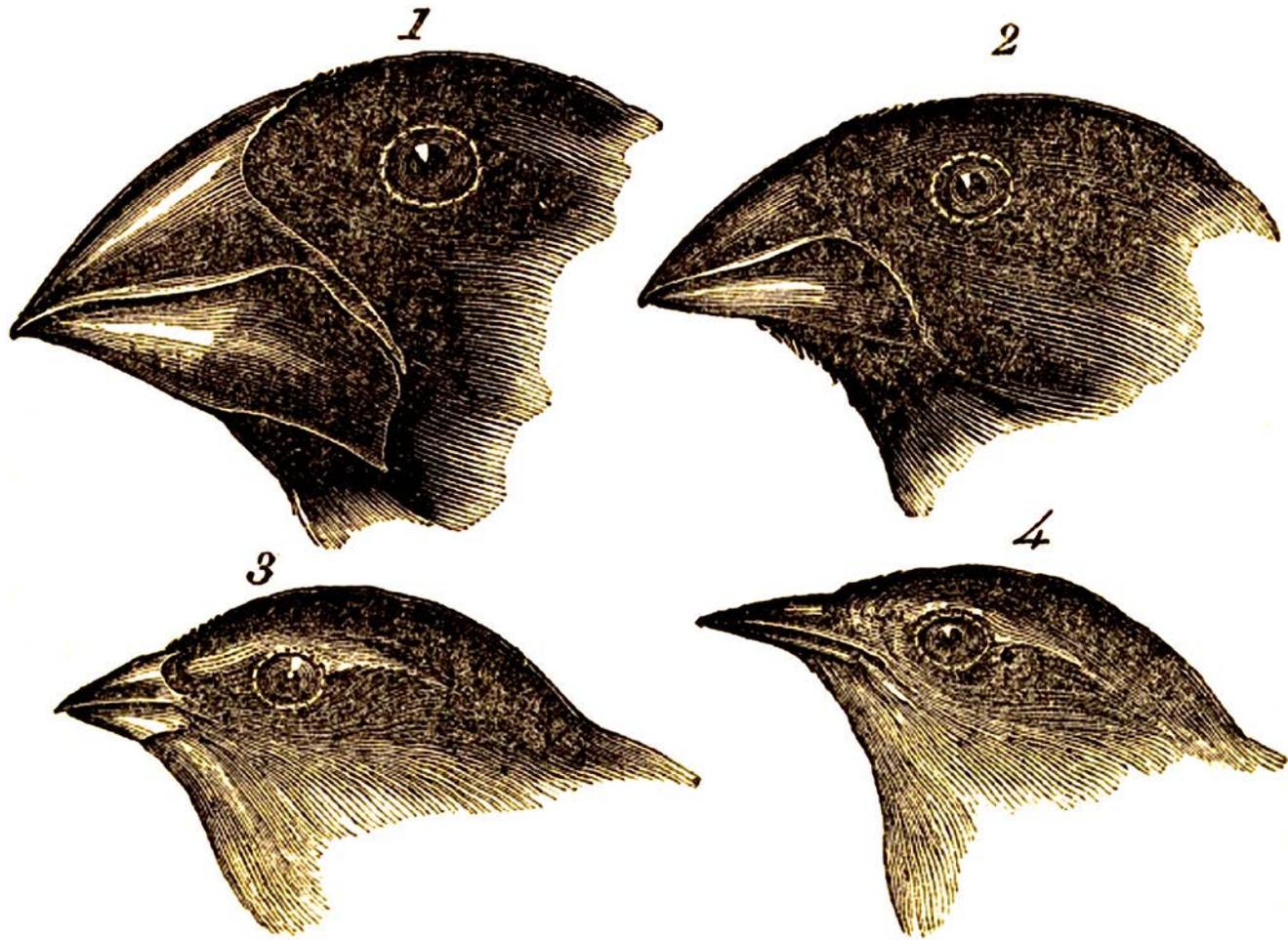
1. Geospiza magnirostris.
3. Geospiza parvula.
2. Geospiza fortis.
4. Certhidea olivacea.

Species Information

- Eight documented subspecies of tiger existed historically.
- As of 2007, only six subspecies remain, and all are listed as endangered.
- Length: average 3 meters.
- Weight: 300 kilograms.
- Lifespan: 15 years in the wild.
- Reproduction: Gestation of 16 weeks, three to four cubs in a litter.

Habitat

- Dense vegetation found in forested areas and a regular water source.
- Currently, they occupy only 7% of their historical range.

Status

- Endangered status is the result of many types of human activities, including hunting for trophies, use of their body parts for medicinal purposes, deforestation of habitat, and loss of food sources.
- Expanding human populations in the region have altered land use practices, increasing habitat loss:
  - Forested regions have been converted to agricultural uses.
  - Commercially valuable tropical woods have been heavily harvested.
  - Expansion of urban areas, including new roads and industrial expansion, has fragmented forest habitats.
  - Hydroelectric dams have altered water sources, decreasing suitable habitat.

VA #16 Tiger Distribution

Tiger's present range
Tiger's historic range

Terai Arc
Landscape

CHINA

INDIA

INDIAN
SUBCONTINENT

INDOCHINA

BAY OF
BENGAL

ANDAMAN
SEA

SOUTH
CHINA
SEA

INDIAN
OCEAN

SOUTHEAST
ASIA

N
W E
S

0   200   500   1,000
Miles
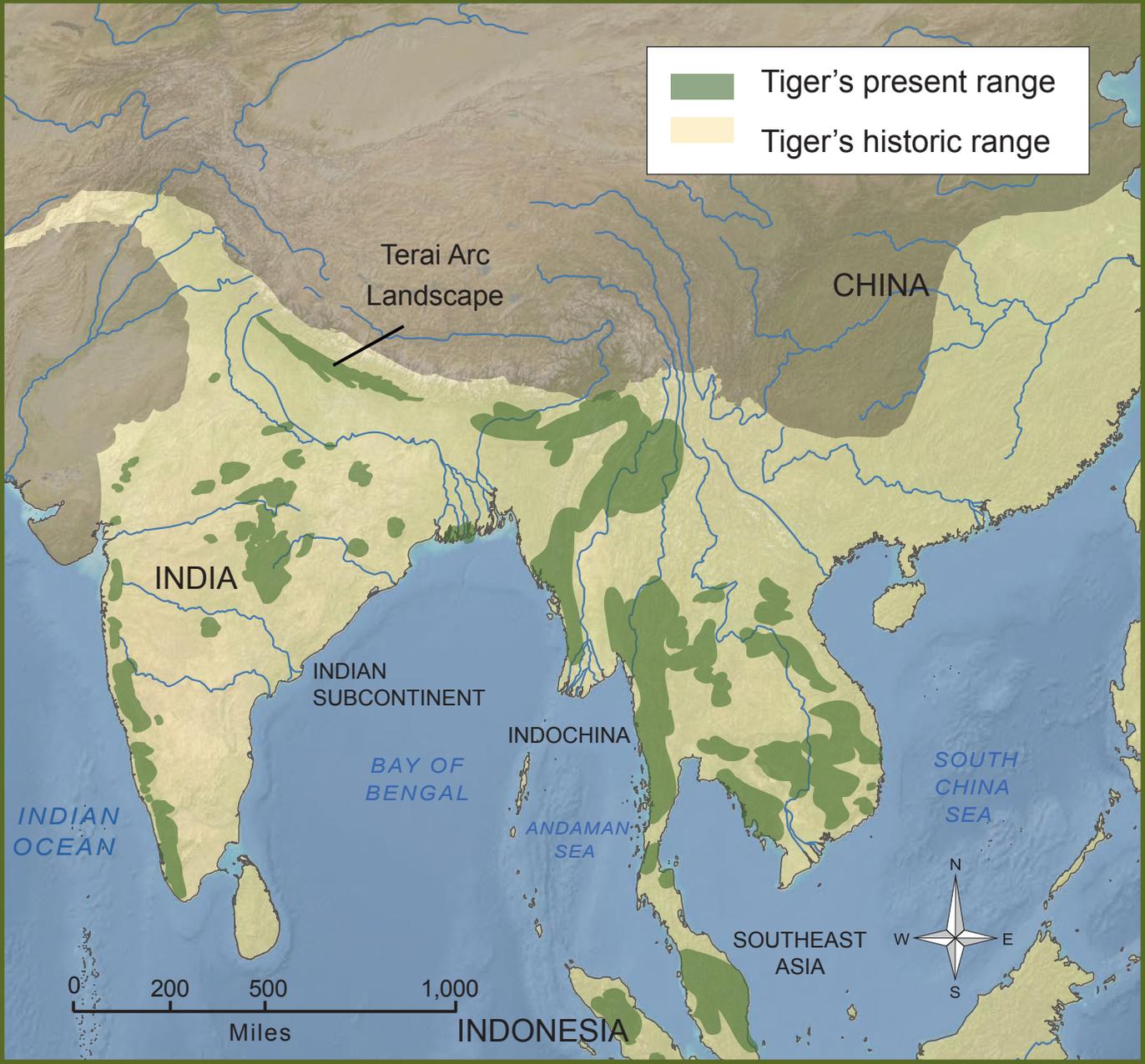
INDONESIA

VA #17 Rice Paddy Distribution in Southeast Asia

< 0.01% of land
covered by
rice paddies

> 50% of land
covered by
rice paddies

China

Japan

Sea of Japan

East
China
Sea

Pacific Ocean

Bay of Bengal

South
China Sea

Indian Ocean

Indonesia

Rice Paddy

N
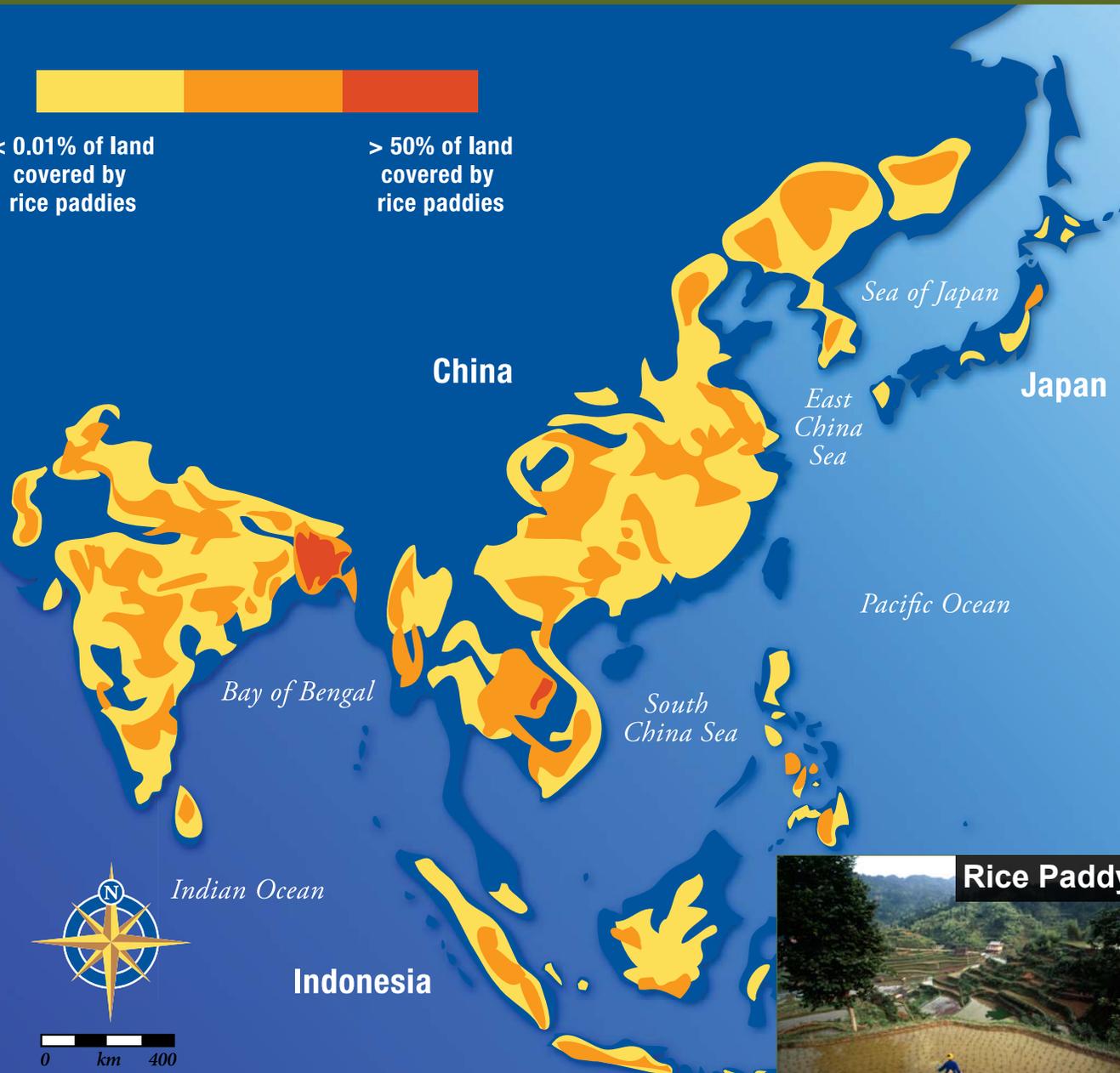
0   km   400

VA #18 Forest Cover of Southeast Asia

Areas with remnants
of dense forest cover

China

Sea of Japan

Japan

East
China
Sea

Pacific Ocean

Bay of Bengal

South
China Sea

N

Indian Ocean

Indonesia

0   km   400

VA #19 Nonnative Species 1

Nonnative Species (Original Location)	Organism Characteristics	Invaded Region	How Introduction Occurred/ Date of Arrival	Former Barrier	Predictions: Influence on Native Species (Plants and Animals)	Consequences: Effects on Geographic Isolation of Native Populations
Blackberry (South America)	Thorny bush that grows in thick hedges up to 4 meters (13 feet) high. Produces thousands of seeds per bush that are viable for many years in the soil. Can reproduce within 3 months after germination.	Galápagos, Ecuador	Unknown 1900s			
Feral Goats (South America)	Strong grazers of vegetation, generalist feeders. Digs in the soil. Reproduces quickly.	Galápagos, Ecuador	Intentional— Ranching 1800s			

VA #20 Nonnative Species 2

Nonnative Species (Original Location)	Organism Characteristics	Invaded Region	How Introduction Occurred/ Date of Arrival	Former Barrier	Predictions: Influence on Native Species (Plants and Animals)	Consequences: Effects on Geographic Isolation of Native Populations
Black Rats (Asia)	Adapts quickly to harsh environments and conditions.	Over 80% of the world's islands, including Channel Islands California, U.S.	Accidental— Exploration ships (invaded every island visited by ships) Unknown			
Red Fire Ant (South America)	Aggressive predators that can sting; territorial.	Galápagos, Ecuador	Hitchhiked on plants and in soil, rafting Early 1900s			

VA #21 Changes in Populations

Group	Increases in Population Numbers	Decreases in Population Numbers
General Animals (applies to all animal groups)	Protected areas Breeding programs Habitat regeneration Protection status	Disease Pollution Decrease in food resources Over-exploitation (hunting/fishing) Increase in predators Loss of suitable habitat
Mammals	Protected areas Breeding programs Habitat regeneration Protection status	Same as "General Animals" plus: Disruption of migratory routes Illegal wildlife trafficking
Birds	Protected areas Breeding programs Habitat regeneration Protection status	Same as "General Animals" plus: Loss of nesting sites is part of loss of suitable habitat Eggs being preyed upon Collection for pet trade
Amphibians	Same as "General Animals" plus: Pollution regulation (very sensitive to pollution due to strong association with water)	Same as "General Animals" plus: Collection for pet trade
Reptiles	Protected areas Breeding programs Habitat regeneration Protection status	Same as "General Animals" plus: Loss of nesting sites Predation on eggs and juveniles Collection for pet trade
Fish	Same as "General Animals" plus: Protected status mainly applies to sharks	Same as "General Animals" plus: Loss of spawning sites Habitat degradation due to algal overgrowth Predation of eggs and larvae Collection for pet trade
Plants	Irrigation Pesticides Restoration Erosion prevention	Diversion of water sources Increased grazing Overgrowth by other plants Loss of habitat Competition for sunlight, water, or nutrients with other plants

Blackberry

The blackberry is at the top of the list for introduced plants that threaten native plant species in the Galápagos Islands. This species often overgrows native species and outcompetes them for space, light, and water. Its seeds are easily dispersed by birds that consume their fruit, allowing the plants to colonize vast areas rapidly. Blackberries also form thick, thorny hedges that cannot be crossed by some animals.

Feral Goats

Goats are strong grazers, so they compete with native species, especially in isolated parts of the Galápagos Islands where vegetation is sparse. They have completely altered natural habitats, changing forested areas into grasslands. The removal of vegetation has increased erosion, further altering the landscape. Additionally, giant tortoises cannot survive where the goats have removed the vegetation because the tortoises no longer have available food or shade critical to their survival in the intense equatorial Sun.

Black Rats

Black rats are a known stowaway on ships since humans began exploring the world. They have been introduced to over 80% of the world's islands. Their introduction is estimated to be responsible for 40–60% of all bird and reptile extinctions in the world. Because the main part of their diet is eggs, black rats can dramatically affect populations of ground-nesting birds. They also eat vegetation, resulting in reduced populations of native plant species. In addition, black rats carry many diseases that can ravage native animal populations. They affect native species by competing with them for similar food resources and preying on them directly.

Red Fire Ants

Red fire ants are one of the most aggressive species that has been introduced into the Galápagos Archipelago. They are believed to have caused a decrease in reptile populations by eating tortoise hatchlings and attacking the eyes of the adult tortoises. They have also caused a reduction of scorpions, spiders, and native ant species. They were probably transported between islands on plants and in soil and on floating vegetation and debris. These ants are very territorial, especially around their nests. As part of their defense, they will attack and sting organisms as large as a juvenile deer. Red fire ants have also reduced populations of native insects that protect plants from insects that eat them. In addition, fire ants consume large amounts of vegetation.

El Niño is a cyclic phenomenon that has a great influence on life in the Pacific Ocean and worldwide effects on climate. It occurs about every 2 to 7 years. The last major El Niño was in 1997–1998; however, several "minor" El Niños have occurred since then. The main indicator of El Niño is warming of ocean surface waters in June and July in the equatorial Pacific. This warm water moves eastward along the Equator toward the Galápagos Islands.

El Niño events have major effects on the usually arid Galápagos Islands. During El Niño years, the islands receive substantially higher amounts of rainfall, leading to a significant increase in plant growth.

Summary of Effects of El Niño:
- increased rain
- increase in fresh water in tidepools
- increased water temperature
- decrease in ocean upwellings that bring nutrients to the surface
- decrease in phytoplankton
- decrease in zooplankton
- decrease in green and red algae
- increase in brown algae
- increase in vegetation growth on land
- increased erosion of rocky surfaces
- increased wave action

VA #24 Rainfall Data

Rainfall (mm) vs **Year**
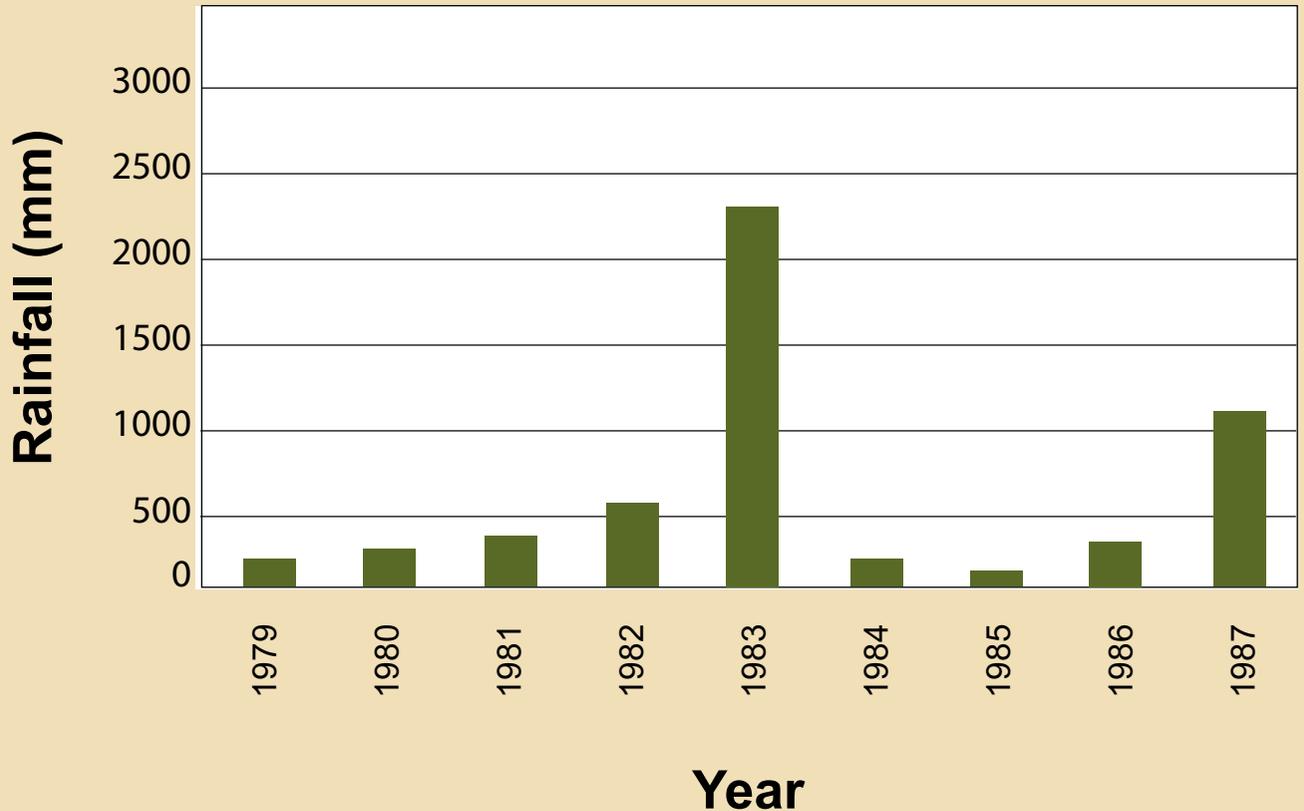
As recorded at the Charles Darwin Research Station in Puerto Ayora, Santa Cruz, Galápagos, Ecuador. Note the increased rainfall during 1983 and 1987, two of the recognized El Niño years.

Fernandina, Galápagos, Ecuador

**Galápagos Penguin and its Rocky Habitat
Bartolomé, Galápagos, Ecuador**

VA #29 Population Changes and El Niño

Animals	Species	Changes in the Population	Influential Parameter
	Marine iguana	30% decrease in body size 50% decline in numbers	Decline in available food resources (red/green algae)
	Flightless cormorant	45% decrease in numbers	Decline in available food resources (fish)
	Galápagos penguin	78% decrease in numbers (1982–1983) Downward population trend	Decline in available food resources (fish)

VA #30 Island Species and Environmental Change

Animal Species	Habitat	Food Source	Behavior	Potential Effects of El Niño on Island-Dwelling Organisms
Marine iguana	Rocky coastal areas, shallow reefs	Red or green algae	Lays eggs in sandy, terrestrial burrows	
Flightless cormorant	Near-shore coastal areas, rocky coastal areas on Fernandina and Western Isabela	Small fish and octopus	Builds seaweed nests in near-shore coastal areas above the high-tide line	
Galápagos penguin	Rocky coastal areas and open ocean	Small fish and crustaceans	Nests in rocky crevices	